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Acidulated pegmatitic mica: A promising new multi-nutrient mineral fertilizer

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Abstract

Scrap grade pegmatitic phlogopite mica contains 5–7% K (~8% K_2O), 10–14% Mg (~23% MgO), 1–2% Ca (~2.9% CaO), 0.03% Mn and 109 ppm Zn. On acidulation upto 65% of K and Mg and 15–100% Mn and Zn were recovered. Less than 13% of Ca was recovered in solution. Water soluble and Nh_4OAc extractable K and Mg of acidulated mica of pegmatitic origin increased a 10^2 to 10^3 times compared to untreated mica. Acidulated mica remained non-hygroscopic even when mixed with acids at a 2:1 mica to acid ratio. X-ray diffraction analyses demonstrated that interlayer cations were easily leached from the mica structure leaving behind a kaolinitic residue, compared to the more stable tetrasilicate feldspars.

The most significant achievement through these experiments was the yield increase obtained in the greenhouse experiment with rice by using the lowest application rate (200 kg ha^{-1}) so far reported for mica, – an exponential decrease from tonnes/ha previously reported. Acidulated phlogopite mica chips (200 kg ha^{-1}– 4 kg K, 8 kg Mg, trace elements Mn, Zn etc.) gave a yield increase of over 41% compared to a control with recommended muriate of potash and dolomite (17 kg K, 6 kg Mg). The response to acidulated feldspar (500 kg ha^{-1}– 1.5 kg K) and an acidulated feldspar-dolomite combined fertilizer (250 kg ha^{-1}– 0.6 kg K and 6 kg Mg) was not significant.

The response to mica clearly shows a multinutrient deficiency in highly weathered tropical soils. The relatively high solubility of the acidulated mica, its range of nutrient element supply, its nonhygroscopic nature and its extremely simple manufacturing process makes mica, a cheap but effective fertilizer for the tropical regions where these nutrients are deficient, especially in highly metamorphosed crystalline terrains.

Introduction

The possibility of using rock powder directly as fertilizer has intrigued some workers (Keller, 1948; Gillman, 1980; Kronberg, 1977; Fyfe et al., 1983). 'Agriculture Alchemy: Stones into Bread' (Chesworth et al., 1983) characterises this attempt. Conventional NPK fertilizers lack many of the vital micronutrients and their continued application may deplete the natural nutrient supply in intensely cultivated, heavily weathered soils found in the tropics (Leonardos et al., 1987). The key factor that makes rock powder attractive when compared to highly soluble commercial fertilizer, is its potential for supplying an array of nutrients, among them the major elements K, cheaply, over a long period of time so that plants can make the most use of it, especially in the tropics. Godefroy et al., (1970) have computed that 60–70% of highly soluble commercial K-fertilizer applied to tropical soils is subject to leaching during the first year. In Sri Lanka, Jayakody and Kendaragama (1989) reported that 50% of the recommended K needed for rice cultivation in the dry zone could be obtained from irrigated waters in the Maheweli system B area. This amount in the irrigated waters is gained through leaching from applied K fertilizers in the intensely cultivated terrains of the catchment areas of the Mahaweli river in Sri Lanka. At present rock powder research spans several continents from Europe (Blum et al., 1989), South America (Salinas et al., 1986; Leonardos, 1987) to Eastern Africa (Chesworth et al., 1989).

The value of volcanic lava and ash in furnishing highly fertile soils is well known (Fyfe et al., 1983). For instance Blum et al. (1989) have shown that volcanic ash can be one of the best rock powder additives for soil amelioration. Smectite rich volcanic ash had a C.E.C. of 45.9 cmol kg^{-1} compared to 3.0 cmol kg^{-1} in a podsol(Ap) and 2.5 cmol kg^{-1} in a pelosol(Ap). Volcanic ash has the ability to provide a high percentage of secondary nutrients, because it is porous and amorphous or finely crystalline. Thus it weathers relatively fast and provides a natural fertilizer (Kronberg, 1977; Salinas et al., 1986).

However, the rejuvenating conditions of periodic volcanism are not felt, in some countries dependent on agricultural economies situated in regions of tropical weathering. Sri Lanka is such a country. It is underlain by a highly metamorphosed, crystalline shield that has remained stable during the past 500 million years, and as such poses a problem regarding the choice of rock powder for use as a cheap but effective fertilizer. Rocks found in crystalline terrains contain significant amounts of quartz which dilute the effectiveness of rocks as a source of K, Ca and Mg from minerals such as feldspars and mica. Nivas et al. (1987) reported the potassium supplying capacity of several commonly found rock types in Sri Lanka. Among them pink granite, granulitic gneiss and migmatitic gneiss had relatively high exchangeable K contents (Table 1). In pegmatites, however, feldspar and mica occur as relatively pure concentrates. Hence the current authors decided to test deposits of alkali-feldspar $[K(Al, Si)_3O_8]$ and phlogopite mica $[K(Mg)_3AlSi_3O_{10}(OH, F)_2]$ of pegmatitic origin also found in Sri Lanka.

Pure mica and feldspar have been tested individually, for their fertilizer value previously, though the results on its efficacy are conflicting. Preliminary unpublished studies using mica and feldspar as straight fertilizer by the present authors have indicated that massive dosages had to be applied to use untreated mica and feldspar as substitute fertilizer for rice cultivation. A 20% yield increase was obtained at an application rate of 10 tons ha^{-1}, but not at lower rates in a field experiment. However without any additional mica the same field was able to provide a 20% yield increase in the next growing season, with only an additional input of N and P. Sanz-Scovino and Rowell (1988) report that finely ground sanidine feldspar gave nonsignificant

Table 1. K_2O content, exchangeable K and C.E.C. of some rocks tested as potential fertilizer in Sri Lanka

Rock Material	Total K (%)		Exchangeable K (meq/100 g)		CEC (meq/100 g)
	(1)	(2)	(1)	(2)	
Phlogopite Mica Dust	4.47	4.51	0.16	0.15	8.17
Kaikawela Feldspar		10.37	0.33	n.a.	1.11
Pink Granite	5.70	5.15	0.10	0.10	0.77
Graphite			0.02	0.02	0.18
Granulitic Gneiss			0.31	n.a.	4.10
Charnockite			0.14	0.13	1.17
Marble			0.01	n.a.	1.08
Bt. Gn.		1.31	0.33	n.a.	2.31
Granulitic Gneiss[a]			0.36		
Migmatic Gneiss[a]			0.314		
Pink Granite[a]			0.351		

[a] Nivas et al. (1987).